NITROGEN TRANSFORMATIONS OF FERTILIZER NITROGEN IN CALCAREOUS SOILS AS AFFECTED BY ORGANIC MATTER, PHOSPHORUS AND LEVEL OF LIME

BY

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FOREWORD

The report which follows is a reproduction of the thesis of Yusuf Nimr Tamimi submitted in partial fulfillment of the requirements for the M. S. Degree granted him in January 1960.

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VITA

Yusuf Nimr Tamimi was born November 15, 1931 at Nablus, Jordan. He attended the Salahyia Secondary School at Nablus and graduated in 1951. He attended the American University of Bierut, Lebanon, for three years, majoring in General Agriculture. In the Spring of 1955, he entered Purdue University, Indiana, and received the degree of Bachelor of Science with a major in General Agriculture in June, 1957. He began graduate work in the field of Agronomy at New Mexico State University in July, 1957, and completed the work for the degree Master of Science in November, 1959.

ABSTRACT

Two incubation experiments were conducted to determine nitrogen transformations in virgin calcareous soils. In Experiment I, top soil of Reeves loam and Reagan sandy loam were used to study the effect of lime level on nitrogen transformations of fertilizers nitrogen, with and without additions of phosphorus. In Experiment II, Reagan sandy loam was used with and without additions of phosphorus and wheat straw to determine their effects on nitrogen transformations when nitrogen fertilizers were added to the soil.

In Experiment I, the Reeves soil with higher level of lime produced more ammonium-nitrogen and less nitrate-nitrogen than the Reagan soil. The addition of phosphorus fertilizers to both soils increased the ammonium- and nitrite-nitrogen levels. Nitrate nitrogen was positively correlated with phosphorus.

In Experiment II, leached and non-leached wheat straw treatments increased the total nitrogen of the soil by about 200 ppm. Straw applications favored higher concentrations of ammonium-nitrogen, and retarded the accumulation of nitrite- and nitrate-nitrogen. Ammonium-nitrogen was correlated positively with phosphorus, readily oxidizable organic matter, and potassium; while nitrate-nitrogen was correlated negatively with readily oxidizable organic matter and potassium.

Fertilizers and straw treatments increased the lime content of the soil.

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INTRODUCTION

In Agriculture, nitrogen is one of the most important nutrient elements in the soil. It is an essential constituent of proteins, which are essential to life.

Nitrogen fertilizers are added to the soil in considerably larger quantities than other nutrients. The nitrogen added to the soil is usually immobilized by the soil microorganisms in a short period of time in the presence of a readily available source of energy. The immobilized nitrogen is later released in part as ammoniacal- nitrite- or nitrate-nitrogen. During these processes of nitrogen transformations, under favorable conditions, portions of the nitrogen are incorporated in organic forms, or volatilized as ammonia, oxides of nitrogen, or free elemental nitrogen. Other portions of the soil nitrogen may be lost by leaching, nitrates being the classical example. The soil expanding clays fix variable portions of the ammonium-nitrogen as non-exchangeable and exchangeable ammonium.

In competition with the above processes, the plants can use the nitrogen left available to them, mainly in the forms of nitrate, ammonium, and nitrite-nitrogen.

There has been extensive research dealing with the factors that influence the changes of nitrogen under numerous conditions. Yet, our knowledge of nitrogen transformations and the factors that influence them still are far from being complete.

This study was designed to investigate the influence of lime, phosphorus, and raw organic matter on the nitrogen transformations in calcareous soils when raw organic matter, phosphorus, and different forms of nitrogen fertilizer were added.

REVIEW OF LITERATURE

Organic Matter

Soil organic matter and plant residue added to the soil influence nitrogen transformations in the soil. It has been noted by several workers (1, 22, 30) that wheat straw applied as top-dressing resulted in lower nitrate content of the soil. Albrecht, and Uhland, (1) reported that the low level of nitrate is caused by heavy mulch application cutting down evaporation, thereby increasing the moisture, lowering the temperature, and preventing the normal exchange of air. All of these symptoms simulate a poor physical condition and unfavorable environment for nitrate accumulation. Mooers, _et al_, (22) attributed the depression in nitrate production to soluble derivatives leached from the mulch into the soil.

The influence of plant residue when incorporated in the soil on the transformations of nitrogen depends on many factors. Some of these factors are noted as the chemical constitution of the residue, the organic matter content of the soil, and the available inorganic constituents in the soil. Other factors that are related to the growth and activities of the soil microorganisms, also, influence these transformations of nitrogen.

When an access of energy material is present in the soil, immobilization or assimilation of inorganic nitrogen takes place, and subsequently, significant quantities of nitrogen are mineralized. The change in energy material favoring the production of nitrate is largely brought about by a depletion of carbon, representing a decrease in the available energy to soil microorganisms (33). The carbon nitrogen relationship in the plant residue undergoing decomposition is a major factor determining the rate and extent of nitrogen release.

Waksman and Tenney (35) suggested that 1.7% nitrogen in decomposing rye was sufficient for microbial needs and that nitrogen in excess of this value was rapidly mineralized. Perbery and Swaby (24) found that sufficient nitrogen for crop needs was released only from materials containing at least 2.5% nitrogen.

Ammonia and nitrate fraction of added fertilizers nitrogen were quickly immobilized in the presence of decomposing wheat straw of .60% nitrogen and corn leaves of 2.98% nitrogen. The nitrogen immobilized by the wheat straw remained immobilized during the eighteen days of the study (24) while nitrification proceeded after a short delay in the presence of corn leaves.

Colom and McCalla (8) investigated nitrate production in sandy soil when alfalfa containing 2.6% N, partridge pea containing 1.9% N, and wheat straw containing .5% N were added. The descending order of nitrate production was alfalfa, partridge pea, and wheat straw. They further found that decomposition of partridge pea residue was increased by the addition of nitrogen This indicated that the plant material was deficient in readily available nitrogen needed by the microorganisms decomposing this residue.

Chapman and Liebig, (7) reported that additions of straw with nitrate and with ammonium compounds, in most cases, decreased nitrate and nitrite concentrations.

Jansson and Clark, (13) reported that inorganic nitrogen increased and organic nitrogen decreased with alfalfa hay additions, while organic nitrogen increased and inorganic nitrogen decreased in equivalent amounts with oat straw additions. The samples were incubated at $26^{o} \pm 1^{o}C$ with inorganic nitrogen and adequate moisture. The alfalfa substrate became alkaline because of rapid ammonification. The oat straw substrate became acidic because of greater immobilization of ammonium nitrogen than of nitrate nitrogen. Further, they show that nitrate-nitrogen appeared to be less readily utilized than ammonium nitrogen in oat straw decomposition. Also, irrespective of pH, there was greater accumulation of organic nitrogen on oat straw substrates in the presence of ammonium-nitrogen than in the presence of nitrate nitrogen.

Pinck, et al, (25) reported that supplemental additions of nitrogen to nitrogen-deficient crop residues are not necessary to hold carbon during the process of humus formation in soils. They concluded that the main effect of nitrogen addition under such conditions was to accelerate the process of humus formation. Where nitrogen was deficient, carbonaceous materials tended to remain in a partly decomposed condition. They also found that when materials with C:N ratios between 18 and 102 were added to the soil, no significant loss of gaseous nitrogen occurred. When the C:N ratios were 3 to 15, marked losses occurred and increased with the increase in nitrogen content. These findings (25) emphasize the importance of carbon in holding nitrogen. MacVicar, et al, (19) using N^{15}, found the largest losses of nitrogen to be associated with a low level of soil organic matter, and a high level of nitrogen application. Active organic matter provides energy for the microorganisms to bring about a reducing environment and thus favors the formation of ammonia (17).

Broadbent and Norman, (5) found that the decomposition of active organic matter will aid the decomposition of soil organic matter, and that the rate of decomposition of the soil organic matter is apparently a function of the amount of the available energy material added to the soil. They also stated that organic soil nitrogen is relatively readily available to active microbial population.

White, et al, (38) found that the cellulose decomposing power of soil, in the laboratory, was highly correlated with the soil pH, with a maximum decomposition of cellulose in three soils at pH 7.2. This relation was not significant in the field plot soils. They also found that there were significant correlations between cellulose-decomposing power and organic matter content, and between cellulose decomposing power and nitrifying capacity of the soils.

Stajanovic and Broadbent, (33) using N^{15}, reported that when ammonium-nitrogen was added with straw or corn leaves to Ontario soil, very little, if any, of the nitrate produced in eighteen days was derived from the added ammonium-nitrogen. Most of the increase in nitrate was derived from organic nitrogen in the corn leaves and the organic fraction of the soil. They concluded that it appears added nitrogen, once immobilized, is not a significant source of mineral nitrogen during relatively short time intervals.

Large amounts of inorganic nitrogen were immobilized by soil organic matter, whether or not organic matter was added to the soil (11, 36, 37). This effect was primarily related to the dynamic microbial cycle (16, 36).

Smith, et al, (31) reported that straw treated plots of a semi-arid soil released nitrate to the plants at a lower rate and over a longer period of time than did plots treated with ammonium sulfate alone. Further, they reported that straw was more favorable than manure to fixation of free nitrogen.

Sabey, et al, (28) found that the rapidity of nitrification was more closely related to the organic carbon content than to the pH. Halvorson and Caldwell (10) have shown a similar relationship where the soils with lower carbon-nitrogen ratios had lower nitrate producing capacity.

Broadbent and Norman, (5) reported maximum losses of nitrogen, probably through denitrification, when nitrate and an energy source were added to soil at the same time. Chapman and Liebig, (7) has not found this to be the case when heavy straw and nitrate nitrogen applications were made.

PHOSPHORUS

It is well known that phosphorus is needed by plants and soil microorganisms to build their cells.

Many workers, more especially Jacobson, et al, (12) have reported phosphorus to be one of the more important and limiting nutrient elements for efficient growth of nitrifying bacteria. It is possible that in alkaline soils, nitrifiers are unable to perform their normal functions because of the lack of essential mineral elements like phosphorus, which are largely unavailable in the soil solution at reactions above pH 7.7 (20).

Krantz, et al, (17) reported that lime, phosphorus, and potassium, in acid soils, increased biological activities, and that the increased microbial population "tied up" more of the applied nitrogen in organic forms. In some black prairie soils of southern Minnesota, Halvorson and Caldwell, (10) found that application of phosphorus and potash had no noticeable effect on nitrification.

At the beginning of humification, several workers (6, 14, 18) have noted that a large part of inorganic phosphorus may be converted into organic compounds, but later after the source of availabile energy has been exhausted, mineralization of phosphorus was detected. Kaila (14) reported that the amounts of cellulose decomposed and organic phosphorus synthesized increased with increasing concentrations of phosphorus in cultures. He estimated that .3% phosphorus is needed for decomposing every unit of organic matter. The microbes utilize phosphorus from the inorganic or organic compounds present. Through autolysis, or the influence of hydrolizing enzymes of the microorganisms, phosphorus is released from the dead cells of the microorganisms and from organic phosphorus compounds of the organic matter.

Soluble soil phosphorus may, also, be fixed by the soil microflora into microbial tissues and cell products. These forms are probably only slightly available to plants. Thompson and Black (34) found both nitrogen and organic phosphorus became more resistant to mineralization as the degree of soil organic matter decomposition advanced, and that of organic phosphorus increased relatively more rapidly than did that of nitrogen.

LIME

One of the main influences of lime on soils is to raise the pH, which in turn influences microbial activities as well as the physical and chemical conditions of the soil.

It has been found that lime and phosphorus additions to soil increased the biological activities (17).

The pH and calcium carbonate content of the soil are important in determining the extent of loss of ammonia by volatilization. Very little loss of ammonia was reported by Martin and Chapman, (21) when neutral or acid ammonium salts were added to neutral or acid soils.

Halvorson and Caldwell, (10), in work on the factors affecting nitrate production in some Minnesota soils, noted that large amounts of calcium carbonate inhibited nitrification. Martin, et al, (20) have suggested that alkalinity may limit, or even prevent, the oxidation of ammonia to nitrate in calcareous desert soils.

METHODS AND PROCEDURE

Two virgin soils, Reeves loam and Reagan sandy loam, were selected for this study. The surface soils, zero to ten inches in the Reeves soil, zero to eight inches in the Reagan soil, were collected, air dried, passed through a 1/4 inch screen and respectively thoroughly mixed. Results of analyses for several soil properties were reported in Table 1.

The two soils were stored for sixty days at 48° F. before the experiment was started.

Wheat straw of low nitrogen content was chopped and passed through a ball mill. A portion of the straw was allowed to stand for two hours in .1 N HC1, and then was leached eight times with .1 N HC1. The straw was leached with distilled water until no chloride ions were detected in the leachate. Both portions of straw, leached and non-leached, were air dried and then dried in a draft oven at 70° C to 10% moisture level.

Sources of nitrogen and phosphorus fertilizers were as follows:

Name	Formula	Grade	Per cent Element
Urea	$CO(NH_2)_2$	Commercial	45 N.
Ammonium Nitrate	NH_4NO_3	Commercial	33 N.
Ammonium Hydroxide	NH_4OH	Lab. Reagent	23.06 N.
Ammonium Sulfate	$(NH_4)_2SO_4$	Lab. Reagent	21.2 N.
Diammonium Phosphate	$(NH_4)_2HPO_4$	Lab. Reagent	21.2 N., 23.5 P.
Treble Super Phosphate	----------	Commercial	19.7 P.

Two replicates from each soil for each fertilizer treatment, Table 2, were prepared. Another two sets from the Reagan soil, one treated with leached straw, and another with non-leached straw at the rate of twenty tons per acre with the same fertilizer treatments as the others, were prepared. The soils, 1.5 pounds for each treatment, after being treated and mixed thoroughly, were placed in glass jars of one liter capacity, and the moisture level was brought up to moisture equivalent level with distilled water. Stoppers that have two glass tubes, 5mm. in diameter, fitted so that one would reach 1/2 inch off the bottom of the jar, and the other would be nearly one inch above the soil surface, to allow air circulation, were fitted on the jars. One group of treatments was incubated for one month, a second for two months, and a third for three months, at $30^{o}C \pm 1^{o}C$. At the end of every period, a group of treatments were removed from the incubator, and jars were fitted with sealed stoppers, placed in a refrigerator, frozen, and kept in this state until analyses were made.

During incubation periods the samples were checked for loss of moisture, once a week, and distilled water was added when needed to keep the moisture content constant.

The soils were analyzed for: total nitrogen (2), ammonium-nitrogen (26), nitrite-nitrogen (26), nitrate-nitrogen, (26), organic matter (27), phosphorus (23), and pH (27). One replicate of the Reagan soil and the treatments with straw additions, were also analyzed for lime (29), total soluble salts (9), and potassium (27).

Correlation and factorial methods of statistical analysis, according to Snedecor (32), were used to aid in the interpretation of the data.

TABLE 1

SOILS ANALYSES FOR REEVES AND REAGAN VIRGIN SOILS

		SOILS	
		Reeves	Reagan
Mechanical Analysis[1]	Sand %	45.8	62.7
	Silt %	34.6	19.4
	Clay %	19.6	17.9
Organic Matter	%	1.26	1.48
Total Nitrogen	%	.066	.092
pH	1:5	8.6	8.4
	Paste	8.0	7.9
Moisture Equivalent[2]	%	17.4	16.3
Total Soluble Salts	%	.07	.03
Lime	%	19.1	8.15
Phosphorus ppm.		9.2	4.4
Potassium ppm.		231	115

1. Pipette method described by Kilmer and Alexander (15)
2. After Briggs and McLane (3)

TABLE 2

FERTILIZER TREATMENTS

Treatment No.	Fertilizer	Pounds per Acre N	Pounds per Acre P
1	None (check)	--	--
2	Urea	120	--
3	Urea & Treble Super Phosphate	120	80
4	Ammonium Nitrate	120	--
5	Ammonium Nitrate and Treble Super Phosphate	120	80
6	Ammonium Hydroxide	120	--
7	Ammonium Hydroxide and Treble Super Phosphate	120	80
8	Ammonium Sulfate	120	--
9	Ammonium Sulfate and Treble Super Phosphate	120	80
10	Diammonium Phosphate	120	132.8

RESULTS AND DISCUSSION

I. The Effect of Fertilizer Treatments and Periods of Incubation on the Nitrogen, Forms and Content, in the Reeves and Reagan Soils.

1. Total Nitrogen

The effect of interaction of fertilizer with period of incubation upon total nitrogen was highly significant; and the effect of the interaction of soil with period of incubation was significant. The data are reported in Tables 3 and 4 respectively.

TABLE 3

THE INFLUENCE OF FERTILIZER INTERACTION WITH PERIOD OF INCUBATION UPON THE TOTAL NITROGEN

Treatment	First Month		Second Month		Third Month		
No.	ppm	1%	ppm	1%	ppm	5%	1%
1	1182[1]	bc+	988	ab	992	ab	a
2	1566	a	960	ab	901	b	a
3	1116	bc	769	b	937	b	a
4	985	bc	1143	a	1035	ab	a
5	1283	ab	924	ab	1046	ab	a
6	1039	bc	1224	a	1161	a	a
7	1184	bc	1050	ab	1068	ab	a
8	961	c	1225	a	1038	ab	a
9	1060	bc	1127	a	1008	ab	a
10	1216	bc	1045	ab	1003	ab	a

L.S.D. t.05 = 220
t.01 = 301

1 Reported are means of four observations.

\+ Any pair of means not followed by the same letter are significantly different at the indicated level of probability.

TABLE 4

THE INFLUENCE OF SOIL WITH PERIOD OF INCUBATION INTERACTION UPON TOTAL NITROGEN

Period of Incubation	Reeves T. N. ppm.	1%	Reagan T. N. ppm.	1%
1st month	1083[1]	a	1235	a
2nd month	1078	a	1011	b
3rd month	989	a	1049	b

L.S.D. t.05 = 98
t.01 = 135

1. Reported are means of 20 observations

In the first month period of incubation, urea and ammonium nitrate + treble super phosphate treatments gave the highest levels of total nitrogen, while ammonium sulfate + treble super phosphate treatment was the lowest in total nitrogen. There was no significant difference between the other treatments.

The overall picture of total nitrogen changed considerably during the second month of incubation. Total nitrogen was decreased significantly for urea, urea + treble super phosphate and ammonium nitrate + treble super phosphate treatments when compared to the total nitrogen at the first month. The only case where total nitrogen increased significantly was in the ammonium sulfate treatment. Total nitrogen in the second month was correlated with potassium, $r = -.648^*$, and with lime, $r = -.706^{**}$. The addition of fertilizer stimulated the growth of microorganisms which broke down portions of the organic matter and contributed to the lowering of the pH. During this process, some of the nitrogen could have been lost in gaseous forms.

* Significant at 5% level of probability.
** Significant at 1% level of probability.

Even though the pH was lowered during the second month, it was found that lime content of the soil increased, this could be caused by the release of CO_2 during the process of organic matter decomposition and subsequent reaction with water and free calcium to form additional quantities of calcium carbonates and calcium bicarbonates.

In the third period of incubation, the total nitrogen status in the soil under the different fertilizer treatments became less variant. At the 5% level of probability, ammonium hydroxide was higher than urea, and urea + treble super phosphate, which were the lowest in total nitrogen. There were no significant differences in total nitrogen between the different fertilizer treatments, at the 1% level. Total nitrogen was correlated significantly with lime $r = -.781^{**}$, potassium $r = -.772^{**}$, pH $r = -.648^{*}$, and readily oxidizable organic matter, $r = .715^{**}$.

There was no significant difference between total nitrogen in the second and third month incubations for the corresponding treatments. When total nitrogen content after three months incubation was compared with that of the first month, only urea and ammonium nitrate + treble super phosphate treatments significantly decreased in total nitrogen in the third month.

Increase in total nitrogen from one incubation period to the other could be caused by (1) fixation of atmospheric nitrogen by soil microorganisms, (2) release of some clay fixed ammonium, (3) and further break down of the acid and base resistant organic matter in the soil by the microorganisms, thus releasing extractable nitrogen compounds.

Meanwhile, any decrease in total nitrogen could be caused by (1) fixation of ammonium ions by the expanding clays, and (2) release and loss of nitrogenous gases during the processes of nitrification. Leaching losses of nitrates and other forms of nitrogen could not take place under the conditions of this experiment.

The effect of soil with period of incubation interaction upon total nitrogen is reported in Table 4. In the Reeves soil, there was no significant change in total nitrogen between the three periods of incubation. However, there was a trend for a continuous decrease in total nitrogen over the three periods of incubation. In the Reagan soil, there was significantly more total nitrogen in the first month than either the second or third month. There was no significant difference in total nitrogen between the second and third month of incubation.

2. Ammonium-Nitrogen.

The variables soil, fertilizer treatment, and period of incubation had a significant influence, over and above the interactions, upon the ammonium form of nitrogen.

Ammonium-nitrogen content of the Reeves soil, Table 5, was significantly higher than the Reagan soil.

TABLE 5

THE EFFECT OF SOIL ON AMMONIUM-NITROGEN

Soil	ppm	5%
Reeves	5.40[1]	a
Reagan	4.40	b

L.S.D. t.05 = .89
t.01 = 1.22

1. Reported are means of 60 observations.

Further, the ammonium-nitrogen content of the soils, for the three periods of incubation, was correlated with potassium, r = .378*, lime r = .325*, and organic matter content, r = -.317*. It is noted that the Reeves soil was higher in lime and potassium and lower in organic matter than the Reagan soil, thus one could expect the Reeves soil to be higher in ammonium-nitrogen content as was found.

Fertilizer effect upon ammonium-nitrogen is reported in Table 6. The check, urea, and urea + treble super phosphate treatments produced significantly higher levels of ammonium-nitrogen than ammonium hydroxide and ammonium sulfate. The other treatments gave no significant differences in concentrations of ammonium-nitrogen found.

TABLE 6

THE INFLUENCE OF FERTILIZER UPON AMMONIUM-NITROGEN

Treatment No.	ppm.	5%	1%
1	6.57[1]	a	a
2	5.87	ab	a
3	6.36	a	a
4	4.34	bc	ab
5	4.92	ab	ab
6	2.85	c	b
7	5.56	ab	ab
8	2.84	c	b
9	5.24	ab	ab
10	4.33	bc	ab

L.S.D. t.05: 2.00 ppm
t.01: 2.73 ppm

1. Reported are means of 12 observations.

There was a trend for ammonium-nitrogen to increase with the addition of phosphorus over the same treatments without phosphorus. This increase in ammonium-nitrogen reached significance with ammonium sulfate and ammonium hydroxide treatments. The addition of phosphorus appears to increase the rate of breaking down the organic matter and the release of ammonium-nitrogen.

At the 1% level of probability, the three periods of incubation, Table 7, were significantly different in ammonium-nitrogen content. The ammonium-nitrogen in the second month was significantly lower than the first and third month incubations. The third month was significantly higher in ammonium-nitrogen than the first month. These differences in the levels of ammonium-nitrogen between the three periods of incubation could be caused by the life cycle of the microorganisms in the soil. A large portion of the ammonium-nitrogen was "tied up" in the bacterial activities during the first and second month incubations, and was released during the third month.

TABLE 7

THE EFFECT OF PERIOD OF INCUBATION ON AMMONIUM-NITROGEN

Month	ppm	1%
1	4.50[1]	b
2	2.95	c
3	7.22	a

L.S.D. t.05: 1.09
t.01: 1.49

1. Reported are means of 40 observations.

For the first month incubation, ammonium-nitrogen was correlated with potassium, r = .740**, lime, r = .817**, pH, r = .868**, and organic matter, r = -.789**. There were no significant correlations for the second month which indicated that the activities of the microorganisms over shadowed the influence of other factors on the ammonium-nitrogen. In the third month, the correlations were similar to the first month; potassium, r = .556*; lime, r = .644*; pH, r = .676**; and organic matter, r = -.706**.

3. Nitrite-Nitrogen.

The period of incubation and fertilizer treatment interaction with period of incubation, Table 8, significantly influenced the nitrite in the soil.

TABLE 8

THE EFFECT OF PERIOD OF INCUBATION, AND FERTILIZER INTERACTION WITH PERIOD OF INCUBATION ON NITRITE-NITROGEN

Treatment No.	First Month ppm	1%	Second Month ppm	5%	1%	Third Month ppm	5%	1%
1	.13[1]	a	.20	bc	bc	.65	ab	a
2	.13	a	.11	d	bc	.41	c	cd
3	.12	a	.10	d	c	.60	b	abc
4	.15	a	.15	cd	bc	.22	d	d
5	.14	a	.31	b	b	.79	a	a
6	.12	a	.16	bcd	bc	.42	c	bcd
7	.11	a	.28	bc	bc	.78	a	a
8	.11	a	.11	d	bc	.62	b	ab
9	.12	a	.98	a	a	.59	b	abc
10	.11	a	.10	d	c	.64	ab	a
L.S.D. t.05: .16 t.01: .21								
Means for Mo.	.12	B	.16		B	.57		A
L.S.D. t.05: .10 t.01: .13								

1. Reported are means of 4 observations.

The third month incubation gave a highly significant increase in nitrite over the first and second month incubations. Although there was no significant difference between the one and two months of incubation, a general trend for nutrite to be increased in the second month was noted.

The fertilizer interaction within the first month incubation on nitrite gave no significant difference between fertilizers.

During the second month incubation, the highest concentrations of nitrite were associated with ammonium sulfate + treble super phosphate, which was significantly higher than the other treatments. Ammonium sulfate + treble super phosphate, ammonium nitrate + treble super phosphate, and ammonium hydroxide + treble super phosphate gave a significant increase in nitrite during the second month over the first month incubation.

With the exception of ammonium nitrate and ammonium sulfate + treble super phosphate, the fertilizer treatments gave a highly significant increase in nitrite during the third month over the first and second month incubations. The nitrite in the three periods of incubation with ammonium nitrate treatment were not significantly different; while with ammonium sulfate + treble super phosphate, nitrite was significantly lower in the third month than the second month, and significantly higher than the first month.

4. Nitrate-Nitrogen.

The soil, fertilizer treatment, and period of incubation had significant effects upon nitrate-nitrogen, over and above all interactions. Soil with fertilizer, and fertilizer with period of incubation interactions significantly influenced the nitrate-nitrogen.

In Table 9, the Reagan soil was significantly higher in nitrate-nitrogen than the Reeves soil. The over-all correlations for nitrate in the three

TABLE 9

THE INFLUENCE OF SOIL, FERTILIZER, AND SOIL WITH FERTILIZER INTERACTION UPON THE NITRATE-NITROGEN

Treatment No.	Reeves ppm	1%	Reagan ppm	1%	Means for Fertilizer ppm	1%
1	28.70[1]	c	44.80	c	36.75	c
2	68.36	b	82.68	ab	75.52	b
3	69.14	b	81.38	abc	75.26	b
4	76.21	ab	76.87	bcd	76.54	ab
5	75.31	ab	76.52	bcd	75.91	b
6	71.73	b	69.28	d	70.51	b
7	71.19	b	73.43	bcd	72.31	b
8	71.79	b	70.70	cd	71.24	b
9	86.20	a	88.85	a	87.52	a
10	77.38	ab	79.87	abcd	78.62	ab
L.S.D. t.05: 8.05 t.01: 11.02					L.S.D. t.05 = 10.38 t.01 = 14.91	
		5%		5%		
Means for	69.60	B	74.44	A		

L.S.D. t.05: 4.64
t.01: 6.67

1. Reported are means of 6 observations.

periods of incubation were with potassium, r = -.385*, lime, r = -.475**, pH, r = -.371*, total soluble salts, r = .414**, organic matter, r = .388*, and phosphorus, r = .384*. Lime, pH, phosphorus, and organic matter content and their effect upon microbial activities might have been the main factors that influenced nitrate-nitrogen production. The Reagan soil compared to the Reeves was lower in lime and pH, and higher in organic matter. The lower lime content and pH, in the Reagan soil, and in the presence of higher organic matter content, favored the microbial activities and the production of more nitrates than the Reeves soil. The increase in nitrate and the lowering of the pH increased the total soluble salts in the two soils. Phosphorus was mineralized along with nitrate-nitrogen. The correlations of potassium with nitrate-and ammonium-nitrogen showed a close similarity to that of lime. This could be caused by a similar influence of potassium and lime on the soil. In green-house studies by Dr. B. C. Williams +, it was noted that the addition of potassium fertilizer with nitrogen reduced yield when compared to the same nitrogen treatment alone, in calcareous soils.

The means of nitrate-nitrogen for periods of incubation, Table 10, were not significantly different in the first and third month incubations. Nitrate-nitrogen in the second month was significantly lower than the first and third month incubations. This decrease and increase in nitrate during these periods of incubation was probably caused by the microbial cycle in the soil. The ammonium-nitrogen, discussed earlier, indicated a similar relationship.

The nitrate was correlated with the pH, $r = -.775^{**}$ at the end of the first month, and with the total soluble salts, $r = .576^{*}$ at the end of the second month; and with potassium, $r = -.582^{*}$, lime, $r = -.641^{*}$, pH, $r = -.827^{**}$, and total soluble salts, $r = .916^{**}$ at the end of the third month.

The interaction of soil with fertilizer upon nitrate-nitrogen is reported in Table 9. Nitrate production in the Reeves soil, as affected by fertilizer

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+ From unpublished studies.

TABLE 10

THE INFLUENCE OF PERIOD OF INCUBATION AND PERIOD OF INCUBATION WITH FERTILIZER INTERACTION UPON THE NITRATE-NITROGEN

Treatment	First Month		Second Month		Third Month		
No.	ppm	1%	ppm	1%	ppm	5%	1%
1	27.43[1]	f	35.49	d	47.34	c	b
2	81.54	bcde	62.69	ab	82.34	ab	a
3	82.97	bcd	64.27	ab	78.55	b	a
4	68.49	e	76.15	a	84.98	ab	a
5	69.76	de	74.52	a	83.46	ab	a
6	70.54	cde	55.84	bc	85.25	ab	a
7	81.33	bcde	56.02	bc	79.58	b	a
8	83.79	bc	47.56	cd	82.38	ab	a
9	100.95	a	70.11	a	91.52	a	a
10	84.28	b	65.62	ab	85.97	ab	a
L.S.D. t.05 = 9.85 t.01 = 13.49							
Month Means	75.10	A	60.83	B	80.14		A
L.S.D. t.05 = 7.89 t.01 = 10.81							

1. Reported are means of 4 observations.

treatment, occurred in the following order: ammonium sulfate + treble super phosphate > diammonium phosphate > ammonium nitrate > ammonium nitrate + treble super phosphate > urea > urea + treble super phosphate > ammonium hydroxide + treble super phosphate > ammonium sulfate > ammonium hydroxide > check.

Although ammonium sulfate + treble super phosphate treatment was significantly higher in nitrate, at the 5% level, than the other treatments, with the exception of diammonium phosphate, yet it was not significantly higher in nitrate, at the 1% level, than diammonium phosphate, and ammonium nitrate treatments. The influence of ammonium sulfate + treble super phosphate on lowering the pH, in the presence of adequate phosphorus and organic matter, appears to be the main factors that caused this significant increase in nitrate-nitrogen over the other fertilizers.

In the Reeves soil, the highest production of nitrate occurred with ammonium sulfate + treble super phosphate, diammonium phosphate, ammonium nitrate and ammonium nitrate + treble super phosphate. The ammonium sulfate + treble super phosphate was significantly higher in nitrate production than the other treatments. It was found that urea and urea + treble super phosphate in the Reagan soil produced significantly more nitrate than when applied to the Reeves soil. The other fertilizer treatments produced similar quantities of nitrate-nitrogen in both soils. The check in the Reagan soil was significantly higher in nitrate than that in the Reeves soil.

Within the Reagan soil, ammonium hydroxide and ammonium sulfate were the lowest in nitrate production. The highest nitrate producing treatments were: ammonium sulfate + treble super phosphate > urea > urea + treble super phosphate and > diammonium phosphate. Ammonium sulfate + treble super phosphate treatment was not significantly higher in nitrate production than the other three treatments mentioned above, but was significantly higher than the remaining treatments reported in Table 9.

The interaction of fertilizer with period of incubation is reported in Table 10. In the first month incubation, ammonium sulfate + treble super phosphate treatment was far superior to the other treatments in nitrate production. It was followed by diammonium phosphate, which was significantly higher than ammonium hydroxide $>$ ammonium nitrate + treble super phosphate and $>$ check treatments. The treatments ammonium sulfate $>$ urea and urea + treble super phosphate $>$ ammonium hydroxide + treble super phosphate and $>$ ammonium hydroxide were not significantly different in nitrate production.

In the second month incubation, all treatments, with the exception of the check, ammonium nitrate, and ammonium nitrate + treble super phosphate, gave a highly significant decrease in nitrate below the corresponding treatments in the first month incubation The check, ammonium nitrate and ammonium nitrate + treble super phosphate gave an increase in nitrate in the second month over the first month. The high concentration of nitrate in the ammonium nitrate treatments could be caused by "carry-over" of some of the nitrate portion of the ammonium nitrate added.

Within the second month incubation, ammonium nitrate + treble super phosphate and ammonium sulfate + treble super phosphate were higher in nitrate production than diammonium phosphate, urea + treble super phosphate and urea treatments, but the differences were not significant. These treatments yielded significantly higher nitrate contents than ammonium hydroxide + treble super phosphate, ammonium hydroxide, ammonium sulfate and the check treatments. The lowest concentrations of nitrate were associated with the check and ammonium sulfate treatments. In the check, where nitrogen or phosphorus fertilizers were not added, the increase in nitrate was, probably, caused by mineralization of nitrogen from the readily oxidizable organic matter, which would be expected to exhibit a more nearly balanced state of equilibrium for the microbial population. In the ammonium sulfate treatment, the pH decreased significantly this with the addition of nitrogen, most probably, disturbed the conditions for microbial equilibrium in the soil and favored the growth of microorganisms. However, the low level of organic matter and phosphorus should limit the growth of the microorganisms and thus retard the mineralization of nitrate during the second month, as the datum indicated.

In the third month, at the 5% level of probability, ammonium sulfate + treble super phosphate was significantly higher in nitrate production than ammonium hydroxide + treble super phosphate and urea + treble super phosphate treatments. All treatments gave highly significant increases in nitrate over the check.

In the third month all fertilizer treatments gave increases for nitrate content over the second month. In all cases, except for ammonium nitrate and ammonium nitrate + treble super phosphate, the increases were statistically significant.

5. Organic Matter

The fertilizer treatment, soil, and period of incubation significantly affected the readily oxidizable organic matter found in the soil.

In Table 11, the influence of fertilizer upon organic matter is reported. It was found that ammonium nitrate + treble super phosphate and diammonium phosphate treatments significantly increased the readily oxidizable organic matter over the other treatments. At the 1% level of probability, the same two fertilizer treatments increased the readily oxidizable organic matter over urea, ammonium sulfate, and ammonium sulfate + treble super phosphate. All other treatments were not significantly different from each other.

The Reagan soil, with 1.36% organic matter, was significantly higher than the Reeves soil which had 1.30% organic matter.

There was a trend for increase in readily oxidizable organic matter

TABLE 11

THE INFLUENCE OF FERTILIZER TREATMENTS UPON THE ORGANIC MATTER OF THE SOIL

Treatment	% O.M.	5%	1%
1	1.46[1]	b	ab
2	1.42	b	b
3	1.46	b	ab
4	1.46	b	ab
5	1.53	a	a
6	1.46	b	ab
7	1.47	b	ab
8	1.45	b	b
9	1.45	b	b
10	1.53	a	a

L.S.D. t.05: .06
t.01: .08

1. Reported are means of 12 observations.

over the length of incubation periods. The second month incubation, 1.47% organic matter, was significantly higher in organic matter than the first month, which contained 1.44% organic matter. The third month, 1.49% organic matter, was significantly higher than the first month, but did not reach significance over the second month incubation.

The additions of nitrogen and phosphorus stimulated the growth of microorganisms which utilized the added nitrogen and phosphorus in breaking down the more acid and base resistant organic matter present in the soil to increase the readily oxidizable forms of organic matter. While this process was going on, breaking down of the readily oxidizable organic matter was proceeding. In general, the rates of the opposing processes favored the build-up of readily oxidizable organic matter during the periods of incubation.

6. Phosphorus.

The fertilizer treatments and period of incubation had a highly significant effect upon phosphorus.

The effects of fertilizer treatments upon phosphorus are reported in Table 12. Diammonium phosphate treatment, 132.8 lbs. of P/acre, significantly increased the extractable phosphorus more than the other treatments. The additions of 80 lbs. of P/acre significantly increased the phosphorus in the soil over the non-phosphorus treatments. Only in the case of the urea + treble super phosphate treatment was the phosphorus level significantly lower than the ammonium sulfate + treble super phosphate treatment. The phosphorus content where nitrogen was applied without phosphorus varied randomly.

Phosphorus decreased significantly in the second month, 24.38 ppm, below the first month, 29.15 ppm., and increased significantly in the third month, 27.00 ppm. However, the third month was significantly lower in phosphorus than the first month.

The phosphorus content of the soil, like the nitrate- and ammonium-nitrogen and pH level followed the microbial cycle. Because of the presence of high concentrations of calcium carbonates, and the alkaline soil reaction, phosphorus might have reacted with calcium compounds or free calcium ions to form less soluble forms of phosphorus, which were not extracted by the sodium bicarbonate method. This might account, in part, for the reduced amount of phosphorus found in the third month. Portions of the phosphorus added were also "tied-up" in the microbial activities and in building the soil organic matter.

7. pH.

The soils, fertilizer treatments, and periods of incubation had inde-

TABLE 12

THE INFLUENCE OF FERTILIZER TREATMENT UPON THE EXTRACTABLE PHOSPHORUS

Treatment No.	ppm	1%
1	15.33[1]	d
2	15.42	d
3	34.25	c
4	13.17	d
5	36.08	bc
6	13.58	d
7	35.75	bc
8	14.58	d
9	37.67	b
10	52.58	a

L.S.D. t.05: 2.43
t.01: 3.32

1. Reported are means of 12 observations.

pendent effects upon the soil pH, over and above the interaction effects. Soil with fertilizer and fertilizer with period of incubation interactions were also significant in their effects upon soil pH.

The Reeves soil, with pH 8.46, had significantly higher pH level than the Reagan soil, with pH 8.37. The over all correlations for the periods of incubation with pH were: potassium, r = .489**, lime, r = .484**, organic matter, r = -.584**, and total soluble salts, r = -.392*. Since the Reeves soil was higher in potassium and lime, and lower in organic matter and total soluble salts, it was expected that the Reeves soil would have a higher pH level than the Reagan soil as was found.

All fertilizer treatments, Table 13, significantly lowered the pH when compared to the check. The lowest pH values were associated with ammonium sulfate and ammonium sulfate + treble super phosphate treatments. These were significantly lower in pH than the other treatments. There was no significant difference in pH, at the 1% level of probability, between the above mentioned treatments and the diammonium phosphate treatment.

The pH level for the periods of incubation was decreased then increased, Table 14. pH values in the first month were correlated with potassium, r = .646*, lime, r = .728**, and organic matter, r = -.761**.

In the second month there were correlations with lime, r = .539*, and total soluble salts, r = -.655**. The increase in total soluble salts during the second month was probably caused by treatment lowering of the pH, and increasing the activities of the microorganisms that released soluble materials. The microbial activities in the second month seems to have minimized and over-shadowed the influence of the other soil factors upon the pH.

In the third month, the pH level increased significantly over the second month. During the third month, the microbial activities appeared to become less vigorous than in the second month and the soil components' effect upon pH, again, were functionally expressed. The pH values in this period were correlated with potassium, r = .792**, lime, r = .867**, organic matter, r = -.757**, and total soluble salts, r = -.392*.

The soil interaction with fertilizer and its influence upon the pH is reported in Table 13. The highest pH levels in the Reeves soil were associated with the check, urea, urea + treble super phosphate, and ammonium hydroxide treatments. The lowest pH levels were associated with ammonium sulfate $<$ ammonium sulfate + treble super phosphate and $<$ ammonium nitrate + treble super phosphate treatments.

The effect of urea and urea + treble super phosphate treatments upon pH in the Reagan soil were extremely different from that in the Reeves soil. These two treatments lowered the pH more in the Reagan soil than in the Reeves soil. In the Reagan soil the following treatments gave the lowest pH levels: ammonium sulfate + treble super phosphate $<$ ammonium sulfate $<$ urea $<$ urea + treble super phosphate and $<$ diammonium phosphate. The pH levels in the other treatments followed the order: check $>$ ammonium nitrate + treble super phosphate $>$ ammonium hydroxide + treble super phosphate $>$ ammonium hydroxide and - ammonium nitrate.

Fertilizer with period of incubation interaction effect upon pH is reported in Table 14. In the first month incubation the pH level of the check was significantly higher than the other treatments. The highest pH values were associated with check $>$ urea + treble super phosphate $>$ urea $>$ ammonium nitrate = ammonium hydroxide = ammonium hydroxide + treble super phosphate and $>$ diammonium phosphate treatments. The lowest pH levels were associated with ammonium sulfate + treble super phosphate $<$ ammonium sulfate and $<$ ammonium nitrate + treble super phosphate.

In the second month, the lowest pH levels were associated with ammonium sulfate $<$ ammonium sulfate + treble super phosphate $<$ and urea + treble super phosphate treatments. All fertilizer treatments gave a significant decrease in pH level in the second month when compared to the pH level of the corresponding treatments in the first month incubation.

After three months incubation, the influence of fertilizer treatments upon pH became more consistent. All fertilizer treatments had significantly lower pH level than the check. Ammonium sulfate and ammonium sulfate + treble super phosphate treatments were significantly lower in pH than diammonium phosphate, ammonium nitrate + treble super phosphate and urea treatments.

It appears that the pH changes during the three periods of incubation followed the microbial cycle that affected ammonium- and nitrate-nitrogen, and phosphorus content of the soil. There were exceptions where ammonium hydroxide and ammonium hydroxide + treble super phosphate treatments gave a continuous decrease in pH over the three periods of incubation; and where ammonium nitrate, ammonium sulfate and ammonium sulfate + treble super phosphate lowered the pH significantly in the second month, but did not change significantly from the second month in the third month incubation.

TABLE 13

THE INFLUENCE OF FERTILIZER AND SOIL WITH FERTILIZER INTERACTION ON THE pH LEVEL

Treatment	Reeves			Reagan			Means for Fertilizer		
No.	pH	5%	1%	pH	5%	1%	pH	5%	1%
1	8.65[1]	a	a	8.52	a	a	8.58	a	a
2	8.54	b	b	8.31	cd	d	8.43	b	b
3	8.51	bc	bc	8.33	c	cd	8.42	b	b
4	8.45	d	cd	8.40	b	bc	8.42	b	b
5	8.37	e	de	8.42	b	b	8.39	b	bc
6	8.46	cd	bc	8.40	b	bc	8.43	b	b
7	8.44	d	cd	8.41	b	bc	8.42	b	b
8	8.31	f	e	8.31	cd	d	8.31	c	c
9	8.35	ef	e	8.27	d	d	8.31	c	c
10	8.45	d	cd	8.33	c	cd	8.39	b	bc

L.S.D. t.05: .06
t.01: .09

L.S.D. t.05: .05
t.01: .06

1. Reported are means of 6 observations

TABLE 14

THE INFLUENCE OF PERIOD OF INCUBATION AND THE FERTILIZER WITH PERIOD OF INCUBATION INTERACTION UPON THE pH LEVEL

Treatment	1st Month			2nd Month			3rd Month		
No.	pH	5%	1%	pH	5%	1%	pH	5%	1%
1	8.78[1]	a	a	8.41	a	a	8.56	a	a
2	8.57	bc	bc	8.32	cdef	abcd	8.39	b	b
3	8.62	b	b	8.28	ef	cd	8.36	b	bc
4	8.56	bc	bc	8.36	abcd	abc	8.34	bc	bc
5	8.47	de	cde	8.33	bcde	abcd	8.38	b	b
6	8.56	bc	bc	8.40	ab	a	8.32	bcd	bc
7	8.56	bc	bc	8.39	abc	ab	8.33	bcd	bc
8	8.43	ef	de	8.25	f	d	8.26	d	c
9	8.38	f	e	8.28	ef	cd	8.27	cd	c
10	8.53	cd	bcd	8.29	def	bcd	8.36	b	b
L.S.D. t.05: .08 t.01: .11									
Means									
for Month	8.54	A	A	8.33	C	B	8.36	B	B
L.S.D. t.05: .03 t.01: .05									

1. Values reported are means of 4 observations

II. The Effect of Fertilizer Nitrogen, with and without Phosphorus, Wheat Straw, and Periods of Incubation Upon Nitrogen Forms in the Reagan Soil.

In this study, the effects of wheat straw treatments and periods of incubation, with the same fertilizer treatments noted previously were investigated.

1. Total Nitrogen.

The total nitrogen status in the Reagan soil was significantly affected by the periods of incubation, and by the straw treatments.

Additions of leached and non-leached straw significantly increased the total nitrogen over the no-straw treatment, Table 15. The increase in total nitrogen, where straw was applied, was about 200 ppm. over the no-straw treatment. It is obvious that the straw which had nitrogen as a constituent, increased the total nitrogen of the soil. Besides, there appears to be evidence of increase in total nitrogen through fixation of atmospheric nitrogen by microorganisms. There was no significant difference between the total nitrogen in the leached and non-leached straw treatments.

As influenced by periods of incubation, Table 16, total nitrogen was significantly higher in the first month than in the second and third month incubations. The third month was higher in total nitrogen than the second month.

During the process of decomposition of added organic matter a considerable loss of nitrogen occurred, as shown by the total nitrogen content in the second month. This loss could have been caused by (1) volatilization of nitrogenous gases, (2) the reversion of nitrogen to form acid and base resistant compounds, (3) the fixation of ammonium ions by the clay.

TABLE 15

THE INFLUENCE OF STRAW UPON TOTAL NITROGEN

Straw Treatment	ppm	1%
No Straw	1049[1]	b
Leached Straw	1258	a
Non-Leached Straw	1240	a

L.S.D. t.05: 102
t.01: 137

1. Reported are means of 30 observations

TABLE 16

THE INFLUENCE OF PERIOD OF INCUBATION UPON TOTAL NITROGEN

Period of Incubation Month	ppm	1%
1	1341[2]	a
2	1033	c
3	1174	b

L.S.D. t.05: 102
t.01: 137

2. Reported are means of 30 observations

The significant increase in total nitrogen in the third month could have been caused by (1) the break down of some acid and base resistant organic matter, (2) the fixation of atmospheric nitrogen by microbial activities, (3) and possibly the release of clay fixed ammonium.

2. Ammonium-Nitrogen.

Straw treatments, Table 17, had a very definite effect upon the ammonium form of nitrogen found in the soil. The leached and non-leached straw treatments gave high concentrations of ammonium-nitrogen as compared to the no-straw treatments. There was no significant difference between the ammonium-nitrogen concentrations in the leached and non-leached straw treatments.

Correlations for ammonium-nitrogen in this study were significant with potassium, r = .568**, phosphorus, r = .329**, and organic matter, r = .810**. Since the added straw was high in potassium, the significant correlation with ammonium-nitrogen might have been an anomaly. Phosphorus was needed by the microorganisms to break down the added straw and thus the increase in phosphorus would stimulate the microbial activities and release more ammonium-nitrogen.

In Table 18, the influence of fertilizer upon ammonium-nitrogen is reported. Although all fertilizer treatments increased the ammonium-nitrogen found over that in the check, only for the ammonium sulfate + treble super phosphate, ammonium hydroxide + treble super phosphate, urea, and ammonium nitrate + treble super phosphate treatments was the increase statistically significant at the 1% level of probability. Since three of these four treatments contained phosphorus and the significance of phosphorus in ammonium-nitrogen production has been previously pointed out it would appear that for ammonium-nitrogen production to proceed normally in a soil, phosphorus supply must be very closely checked.

3. Nitrate-Nitrogen.

The straw treatments, periods of incubation and fertilizer interaction

TABLE 17

THE INFLUENCE OF STRAW UPON AMMONIUM-NITROGEN

Straw Treatment	ppm.	1%
No Straw	3.9[1]	b
Leached	71.2	a
Non-leached	78.6	a

L.S.D. t.05: 10.0
t.01: 13.4

1. Reported are means of 30 observations.

TABLE 18

THE INFLUENCE OF FERTILIZER UPON AMMONIUM-NITROGEN

Treatment No.	ppm.	5%	1%
1	31.4[2]	d	c
2	58.5	a	ab
3	53.1	ab	abc
4	52.7	ab	abc
5	58.5	a	ab
6	35.6	bd	bc
7	56.3	a	ab
8	53.7	ab	abc
9	60.5	a	a
10	52.3	ab	abc

L.S.D. t.05: 18.2
t.01: 24.4

2. Reported are means of 9 observations

with straw treatment had a highly significant effect upon nitrate-nitrogen production.

The addition of straw retarded the accumulation of nitrate-nitrogen in the soil, Table 19; while nitrification in the no-straw treatment followed a normal path and accumulation of nitrate occurred. There was no significant difference between leached and non-leached straw in the production of nitrate, although the leached straw treatments tended to have more nitrate-nitrogen produced.

The production of nitrate during the three periods of incubation, Table 19, decreased non-significantly during the second month and significantly increased in the third month of incubation over the first and second month incubations. The accumulation of nitrate-nitrogen for the leached straw, when it occurred, started in the second month and increased in the third month of incubation. In the non-leached straw treatment nitrate accumulation, when it occurred, did not appear until the third month of incubation. The high concentrations of ammonium-nitrogen, associated with the straw treatments, might have had an inhibiting effect upon the nitrite and nitrate. A fast utilization of the produced nitrite and nitrate by the microorganisms in the abundance of carbohydrates could also prevent the accumulation of these forms of nitrogen. It was noted in several cases that wherever nitrate accumulation took place, in the straw treatments, the ammonium-nitrogen concentration decreased significantly and nitrite-nitrogen was found in higher concentrations. These findings are in accord with the classical assumption that nitrite-nitrogen is an intermediate product during the transformations of ammonium-nitrogen to nitrate-nitrogen.

TABLE 19

THE INFLUENCE OF STRAW TREATMENTS AND PERIODS OF INCUBATION UPON NITRATE-NITROGEN

Month	No Straw ppm.	Leached ppm.	Non-Leached ppm.	Means for Periods ppm.	1%
1	76.48[1]	1.03	.78	26.09	b
2	61.58	11.13	.73	24.48	b
3	81.39	23.37	11.58	38.78	a
Means for Straw Treatments	73.15	11.84	4.36	L.S.D. t.05: 7.19 t.01: 9.64	

L.S.D. t.05: 13.74
t.01: 18.82

1. Reported are means of 10 observations.

TABLE 20

THE INFLUENCE OF FERTILIZER WITH STRAW INTERACTION ON THE NITRATE-NITROGEN

Treatment No.	No Straw ppm.	Leached Straw ppm.	Non-Leached Straw ppm.
1	43.21[2]	20.04	16.56
2	81.00	34.66	2.46
3	80.87	.93	17.09
4	76.64	1.06	1.32
5	74.47	1.22	1.07
6	69.98	55.88	1.26
7	71.59	1.17	.93
8	70.27	1.19	.92
9	85.96	1.20	.90
10	77.51	1.04	1.12

L.S.D. t.05: 22.74
t.01: 30.50

2. Reported are means of 3 observations.

The interaction of fertilizer with straw and its influence upon the nitrate-nitrogen is reported in Table 20. The production of considerable concentrations of nitrate were associated with the check, urea, and ammonium hydroxide treatments, where leached straw was added to the soil; and with the check and urea + treble super phosphate treatments where non-leached straw was applied.

4. Organic Matter.

Straw treatments, Table 21, had a highly significant effect upon the readily oxidizable organic matter, over and above any interaction. The straw treatments interaction with periods of incubation had significant effect upon the readily oxidizable organic matter, Table 21.

The leached and non-leached straw applications increased the readily oxidizable organic matter significantly over the no-straw treatment. There was no significant difference between leached and non-leached straw additions in increasing the readily oxidizable organic matter.

In the straw treatments, readily oxidizable organic matter was highest in the first month followed by a decrease in the second month and an increase in the third month. These changes in organic matter failed to reach the level of significance for leached straw treatment. In the non-leached straw treatment, the first month was significantly higher in readily oxidizable organic matter than the second and third month incubations, at the 5% level of probability. The leached straw had most of its acid-soluble organic materials removed in the process of leaching, thus the non-leached straw had more soluble organic matter at the beginning of the study. The decrease in readily oxidizable organic during the second month incubation could be caused by (1) ready decomposition to CO_2, (2) "tie-up" in the cells and activities of the microorganisms, (3) or reversion

TABLE 21

THE EFFECT OF STRAW TREATMENTS AND STRAW WITH PERIOD OF INCUBATION INTERACTION ON THE READILY OXIDIZABLE ORGANIC MATTER

Month	No Straw %	1%	Leached Straw %	1%	Non-Leached Straw %	5%	1%
1	1.64[1]	a	2.53	a	2.64	a	a
2	1.66	a	2.46	a	2.46	b	b
3	1.72	a	2.50	a	2.49	b	ab
L.S.D. t.05: .12 t.01: .16							
Average % O.M. for Straw Treatments	1.67	B	2.50	A	2.53		A
L.S.D. t.05: .18 t.01: .30							

1. Reported are means of 10 observations.

TABLE 22

THE EFFECT OF STRAW ON PHOSPHORUS

Straw Treatment	ppm.	1%
No Straw	26[2]	b
Leached	36	a
Non-Leached	35	a

L.S.D. t.05: 2
t.01: 3

2. Reported are means of 30 observations.

to non-readily oxidizable forms. By the end of the third month, part of the non-readily oxidizable forms had been broken down to the readily oxidizable forms.

5. Phosphorus.

The phosphorus status was affected significantly by the straw treatments, periods of incubation, fertilizer treatments, and periods of incubation with fertilizers interaction.

The additions of leached and non-leached straw, Table 22, significantly increased the phosphorus over the no-straw treatment. This would be expected since the added straw contained some phosphorus.

In Table 23, the extractable phosphorus was significantly higher in the first month incubation than the second month, but was not significantly different from the third month incubation. The phosphorus extracted at the end of the third month was not significantly higher than the second month. The decrease in phosphorus during the second month incubation could be caused by its utilization in build-up of the microbial population; and could be fixed in several other non-extractable forms in the presence of lime at the pH levels of this experiment. Some mineralization of phosphorus apparently occurred in the third month. This could account for the increase found.

In the fertilizer treatments, Table 23, the addition of 132.8 lbs. of P/acre in the diammonium phosphate treatment gave a highly significant increase in extractable phosphorus over all other treatments. The additions of 80 lbs. of P/acre in treble super phosphate form caused a highly significant increase in extractable phosphorus in the soil. The different nitrogen fertilizers had no significant influence upon the phosphorus status in the soil.

The period of incubation interaction with fertilizer is reported in Table 23. During the three periods of incubation, diammonium phosphate treatment was significantly higher in phosphorus than the other treatments; even though it dropped significantly in the second month. All treatments where treble super phosphate was added, contained significantly higher levels of phosphorus than the non-phosphorus treatments in the three periods of incubation, with the exception of ammonium nitrate + treble super phosphate in the third month. Phosphorus level in this treatment was not significantly higher than in the ammonium hydroxide treatment. There was no significant difference between the non-phosphorus treatments within the three periods of incubation. Phosphorus content decreased significantly in the second month, as compared to the first month, in the ammonium nitrate + treble super phosphate, ammonium sulfate, and diammonium phosphate treatments. The level of phosphorus increased significantly in the third month over the second month only in the ammonium hydroxide, and diammonium phosphate treatments.

6. pH.

The period of incubation was the only factor that influenced the pH level significantly, Table 24. At the end of the first month, the pH level was significantly higher than at the end of the second or third month incubations. There was no significant difference between the pH levels at the end of the second and third month incubations.

The pH level within the three periods of incubation gave a highly positive correlation with the lime content and negative with total soluble salts. At the end of the first month, the total soluble salts content of the soil was lower than the other periods, while the lime content was high. This relation favored the lime content to induce a higher level of pH in this period of

TABLE 23

THE EFFECT OF FERTILIZER AND PERIOD OF INCUBATION ON PHOSPHORUS

Treatment No.	1 Month ppm	1%	2 Months ppm	1%	3 Months ppm	1%	Means for fertilizer ppm	1%
1	21[1]	c	19	c	24	d	21	c
2	23	c	23	c	22	d	23	c
3	41	b	35	b	39	b	39	b
4	19	c	19	c	22	d	20	c
5	53	a	39	b	32	bc	41	b
6	25	c	18	c	26	cd	23	c
7	43	b	37	b	36	b	39	b
8	26	c	18	c	22	d	22	c
9	43	b	39	b	39	b	40	b
10	59	a	49	a	58	a	55	a
L.S.D. t.05: 8 t.01: 10							L.S.D. t.05: 7 t.01: 9	
Means for Months	35	A	30	B	32	AB		

L.S.D. t.05: 4
t.01: 5

1. Reported are means of three observations.

incubation. During the second and third month incubations, the microbial activities were higher than during the first month, and thus producing more organic acids and other by-products of acidic nature, like CO_2, increased the total soluble salts. All of these activities over-shadowed the influence of the high lime content on the pH and a significant decrease in pH level occurred.

Even though the straw treatments did not give a statistically significant influence upon the pH level of the soil, yet it should be noted that the leached straw treatment raised the pH level while the non-leached straw treatment lowered the pH level of the soil when both were compared to the no-straw treatment, Table 25.

Leaching the straw appears to have washed out some straw contents of acidic nature and thus increased the ratio of those with basic nature in reaction which might have contributed to raising the pH level of the soil.

TABLE 24

THE INFLUENCE OF PERIOD OF INCUBATION UPON THE pH LEVEL

Month	pH	1%
1	8.55[1]	a
2	8.26	b
3	8.28	b

L.S.D. t.05: .17 t.01: .23

1. Reported are means of 30 observations.

TABLE 25

THE INFLUENCE OF STRAW TREATMENTS UPON pH LEVEL

Straw Treatment	pH
No Straw	8.35[2]
Leached	8.46
Non-Leached	8.28

2. Reported are means of 30 observations.

7. Lime.

The period of incubation and straw treatment significantly affected the status of lime in the soil.

At the end of the second month incubation, the lime content of the soil was significantly higher than at the end of the first or third month incubations, Table 26. During the second month, it seems that the microbial activities were at their optimum and the production of CO_2 was higher than in the first or third month. The production of CO_2 in the presence of H_2O produced carbonic acid which reacted with the free calcium and potassium and other free cations to form carbonates and bicarbonates thus increasing the carbonate and bicarbonate concentration in the soil. In the third month, the decrease in CO_2 production by the apparent decrease in microbial activities might have favored the reverse of the above mentioned process resulting in a decrease in the carbonate and bicarbonate content of the soil.

The leached straw treatment was significantly higher in lime content than no-straw and non-leached straw treatments, Table 27. All treatments increased the lime content of the soil over the virgin conditions which was 8.15%.

TABLE 26

THE EFFECT OF PERIOD OF INCUBATION ON LIME CONTENT OF THE SOIL

Month	% Lime	1%
1	8.67[1]	b
2	9.05	a
3	8.58	b

L.S.D. t.05: .23 t.01: .31

1. Reported are means of 30 observations.

TABLE 27

THE EFFECT OF STRAW TREATMENT ON LIME CONTENT OF THE SOIL

Straw Treatment	% Lime	5%	1%
No Straw	8.69[2]	b	ab
Leached	8.97	a	a
Non-Leached	8.63	b	b

L.S.D. t.05: .23 t.01: .31

2. Reported are means of 30 observations.

8. Total Soluble Salts.

The straw treatment and period of incubation interaction with straw treatment significantly affected the total soluble salts found in the soil, Table 28.

The total soluble salts content of the soil under its virgin conditions was .030%, Table 1. It was found that the no-straw treatment increased total soluble salts to reach an average level of .145%. The leached straw treatment was not significantly lower in total soluble salts than the no-straw treatment, while the non-leached straw gave significantly higher level of total soluble salts than no-straw and leached straw treatments.

For the three periods of incubation, total soluble salts were correlated, in the no-straw treatment, with potassium, r = -.372*, lime, r = -.453**, and pH, r = -.392*; and in the leached straw, with lime, r = -.378*, and pH, r = -.833**; and in the non-leached straw treatment with pH, r = -.415**. In agreement with these correlations the lime and pH level were lower in the no-straw treatment than in the leached straw treatment, which had greater microbial population and activities. The microorganisms might have used some of the soluble salts in their activities, thus lowered the total soluble salts content of the soil. The non-leached straw had more total soluble salts than the leached straw, besides, the lime and pH level of the non-leached straw treatment were lower than that of the leached straw treatment. These relations favored the non-leached straw treatment to give a significantly higher level of total soluble salts than the leached straw treatment.

The interaction of straw treatment with period of incubation gave a general trend that the longer the period of incubation the more production of soluble salts, Table 28.

In the no-straw treatment, there was an increase in total soluble salts during the third month, although the three periods of incubation were not significantly different. The second and third month incubations with leached straw treatment were significantly higher in total soluble salts than the first month. In the non-leached straw treatment the following significant relationship for total soluble salts was found: third month > second month > first month. This trend in total soluble salts status could be caused by the release of microbial by-products, and the changes in pH level along the three periods of incubation.

TABLE 28

THE EFFECT OF STRAW AND ITS INTERACTION WITH THE PERIOD OF INCUBATION ON THE TOTAL SOLUBLE SALTS

Period of Incubation Month		No Straw % T.S.S.	1%	Leached Straw % T.S.S.	1%	Non-leached Straw % T.S.S.	1%	Means for Months % T.S.S.
1		.144[1]	a	.106	b	.169	c	.139
2		.143	a	.131	a	.187	b	.154
3		.148	a	.136	a	.214	a	.166
L.S.D.	t.05:	.014						
	t.01:	.018						
Means for Straw		.145	B	.124	B	.190	A	
L.S.D.	t.05:	.026						
	t.01:	.043						

1. Reported are means of 10 observations.

9. Potassium.

The straw treatment and the period of incubation interactions with fertilizer and straw treatment significantly influenced the potassium content of the soil.

The level of potassium in soil as affected by straw treatments followed the order: non-leached straw $>$ leached straw $>$ no straw, with highly significant differences between the treatments, Table 29. Leaching the straw with HC1, apparently, did not extract all potassium in the straw, thus the leached straw contributed to the potassium content of the soil. The non-leached straw was high in potassium and its application to the soil increased the potassium level significantly.

In the period of incubation interaction with fertilizer, Table 30, the following treatments: ammonium hydroxide, ammonium sulfate, ammonium sulfate + treble super phosphate and diammonium phosphate maintained a high level of potassium through the three periods of incubation. Ammonium nitrate gave a continuous increase in potassium level during the three periods, while potassium level in the other treatments varied randomly.

The period of incubation interaction with straw treatments is reported in Table 29. The non-leached straw was the only treatment where the period of incubation affected the potassium level significantly. The potassium level in relation to period of incubation was in this order: second month $>$ third month $>$ first month. These changes could be caused by further physical and chemical break down of added straw to render its potassium extractable. In the third month, it appears that the "tie-up" of potassium in the microbial activities was more than its release, thus the potassium level decreased significantly in the third month of incubation.

As pointed out previously, when potassium was found in high concentrations, it apparently was similar to lime in its influence on total soluble salts, organic matter, pH level, ammonium- and nitrate-nitrogen production. It is possible that there was an interaction between lime and potassium. Further studies of these relations are needed.

TABLE 29

THE EFFECT OF PERIOD OF INCUBATION AND STRAW TREATMENT ON THE POTASSIUM LEVEL IN THE SOIL

Period of Incubation	No Straw		Leached Straw		Non-Leached Straw		
Month	ppm	1%	ppm	1%	ppm	5%	1%
1	150[1]	a	217	a	476	c	b
2	144	a	220	a	535	a	a
3	148	a	223	a	520	b	a
L.S.D. t.05:	13						
t.01:	18						
Means for Straw	147	C	220	B	510		A
L.S.D. t.05:	41						
t.01:	68						

1. Reported are means of 10 observations.

TABLE 30

THE EFFECT OF FERTILIZER AND PERIOD OF INCUBATION ON THE POTASSIUM IN THE SOIL

Treatment	1 Month			2 Months			3 Months		
No.	ppm	5%	1%	ppm	5%	1%	ppm	5%	1%
1	272[1]	bc	b	266	e	d	278	c	bc
2	286	ab	ab	288	cde	bcd	282	c	abc
3	287	ab	ab	292	cd	bcd	287	bc	abc
4	266	bc	b	293	cd	bcd	313	a	a
5	282	abc	ab	276	de	cd	275	c	c
6	286	ab	ab	317	ab	ab	308	ab	ab
7	260	c	b	310	abc	ab	309	ab	ab
8	305	a	a	300	bc	abc	312	a	a
9	282	abc	ab	327	a	a	310	ab	ab
10	282	abc	ab	326	a	a	296	abc	abc

L.S.D. t.05: 24
t.01: 33

Means for Months	271	300	297

1. Reported are means of 3 observations.

SUMMARY AND CONCLUSIONS

Two incubation experiments were conducted to determine nitrogen transformations that occur in calcareous soils. In Experiment I, Reeves loam and Reagan sandy loam soils were used to study the effects of lime level on transformation of fertilizer nitrogen, with and without phosphorus. In Experiment II, Reagan sandy loam soil was used with and without additions of phosphorus and raw organic matter to determine the effects of phosphorus and raw organic matter additions on nitrogen transformations when nitrogen fertilizers were added to the soil.

Effects of fertilizer and straw additions upon some soil properties were also studied.

Experiment I.

Total nitrogen in the Reeves and Reagan soils decreased with time. Losses of nitrogen appeared to have taken place during the third month in the Reeves soil, and during the second month in the Reagan soil. Total nitrogen was correlated negatively with potassium, lime and pH, and positively with the readily oxidizable organic matter found in the soils.

Ammonium-nitrogen was correlated positively with potassium and lime, and negatively with readily oxidizable organic matter. Thus, it was found that the accumulation of ammonium-nitrogen was higher in the Reeves soil than in the Reagan soil. It was also found that treatments which included phosphorus gave a higher ammonium-nitrogen concentration than those without phosphorus. Ammonium-nitrogen decreased in the second month of incubation and increased in the third month of incubation. This trend was caused, probably, by the microbial life cycle and their activities in the soil.

Nitrite nitrogen was found to increase in the third month of incubation.

As with ammonium-nitrogen, higher nitrite-nitrogen concentrations were associated with fertilizer treatments that included phosphorus.

Nitrate production was correlated negatively with potassium, lime, and pH, and positively with readily oxidizable organic matter, phosphorus, and total soluble salts. In accord with these relations, it was found that the Reagan soil produced more nitrate-nitrogen than the Reeves soil. The similar effect of potassium to lime upon total nitrogen, ammonium- and nitrate-nitrogen needs further studies. Nitrate nitrogen content, like other soil constituents, followed the microbial activities. There was a decrease in nitrate-nitrogen during the second month followed by an increase in the third month incubation.

All fertilizer treatments increased the readily oxidizable organic matter in both soils over the check. The highest levels were associated with ammonium nitrate + treble super phosphate and diammonium phosphate treatments. The readily oxidizable organic matter increased with time.

The addition of phosphorus fertilizers to the soil increased the extractable phosphorus. Phosphorus levels during the periods of incubation were also influenced by the microbial cycle which resulted in a decrease in phosphorus during the second month, followed by an increase during the third month incubation.

It was found that all fertilizer treatments lowered the pH levels in both soils. The lowest levels were associated with ammonium sulfate and ammonium sulfate + treble super phosphate treatments. The pH levels were correlated positively with potassium and lime, and negatively with readily oxidizable organic matter and total soluble salts. In accord with these relations, the Reeves soil had a higher pH level than the Reagan soil. The pH levels were also affected by the microbial cycle. The effects of other soil constituents upon pH levels were overshadowed by the high microbial activities during the second month.

Experiment II.

Total nitrogen in the Reagan soil was increased by about 200 ppm. of nitrogen where wheat straw was applied. Total nitrogen in the soil decreased during the second month and later increased in the third month incubation. Nitrogen losses could be caused by volatilization of nitrogenous gases during the breakdown processes of raw organic matter. Fixation of atmospheric nitrogen could account for some of the increase in total nitrogen during the third month incubation.

Where straw was applied, ammonium-nitrogen persisted in high concentrations during the three periods of incubation. Ammonium-nitrogen was correlated positively with potassium, phosphorus, and readily oxidizable organic matter.

The additions of straw, leached and non-leached, retarded the accumulation of nitrite- and nitrate-nitrogen in the soil. In the leached straw treatments, the check, urea, and ammonium hydroxide treatments gave accumulation of nitrite- and nitrate-nitrogen. In the non-leached straw accumulation of these forms of nitrogen occurred only with the check and urea + treble super phosphate treatments. Wherever there was accumulation of nitrite- and nitrate-nitrogen, ammonium-nitrogen content in the soil decreased significantly. Nitrification in the no-straw treatments followed a normal path, and accumulations of nitrate-nitrogen occurred. These findings are in agreement with the classical assumption that nitrite is an intermediate product in the transformations of ammonium-nitrogen to nitrate-nitrogen.

The leached and non-leached straw treatments increased the readily oxidizable organic matter in the soil.

The different nitrogen fertilizers had no significant influence upon the phosphorus status in the soil. The addition of straw and phosphorus fertilizers significantly increased the extractable phosphorus.

It was found that the pH level decreased significantly during the second month and was slightly increased during the third month. This trend could be caused by the microbial cycle. When compared to the pH level in the no-straw treatments, leached straw induced a higher pH level, while non-leached straw lowered the pH level of the soil.

Lime content of the soil as affected by treatments followed this order: leached straw $>$ no straw $>$ non-leached straw. Periods of incubation gave the following effect upon lime in the soil: Second month $>$ first month $>$ third month.

Total soluble salts were correlated negatively with potassium, lime and pH level, in the no-straw treatment; and negatively with lime and pH in the leached straw treatment; and negatively with pH level in the non-leached straw treatment. Total soluble salts as affected by straw treatments were found in this order: non-leached straw $>$ no straw $>$ leached straw.

The non-leached straw significantly increased the potassium in the soil more than the leached straw treatment. Higher levels of potassium were associated with ammonium hydroxide, ammonium sulfate, ammonium sulfate + treble super phosphate, and diammonium phosphate treatments.

As pointed out previously in the study, when potassium was found in high concentrations in the soil, it apparently had a similar effect to lime upon total nitrogen, ammonium- and nitrate-nitrogen production, and upon readily oxidizable organic matter, pH, and total soluble salts. It is possible that there was an interaction between lime and potassium in the soil. Further studies of these relations are needed.

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SOIL ANALYSES

Reeves

1st Month

Treatment No.	T. N. ppm		NH_4-N ppm		NO_2-N ppm		NO_3-N ppm		O. M. %		Phosphorus ppm		pH	
1	1067	991	10.6	11.9	.13	.09	14.06	21.14	1.24	1.27	19	17	8.81	8.90
2	1501	1487	5.8	5.3	.13	.16	73.04	71.52	1.25	1.22	18	19	8.70	8.65
3	1047	1053	8.3	8.1	.10	.09	82.14	81.63	1.30	1.28	32	34	8.71	8.70
4	1036	1031	4.6	3.9	.16	.14	70.01	68.94	1.26	1.27	15	12	8.60	8.65
5	947	967	4.2	4.1	.15	.12	70.74	71.10	1.32	1.34	41	38	8.43	8.40
6	985	964	.8	1.4	.13	.11	72.33	71.13	1.21	1.25	15	17	8.60	8.55
7	1147	994	5.6	6.0	.09	.12	78.92	74.20	1.36	1.31	41	38	8.60	8.60
8	984	1031	1.1	1.4	.11	.13	82.93	83.54	1.25	1.23	17	15	8.40	8.35
9	1045	991	6.3	5.8	.12	.12	101.14	98.65	1.30	1.27	38	40	8.45	8.35
10	1246	1140	5.8	5.4	.09	.13	83.46	82.44	1.34	1.32	61	58	8.60	8.65

SOIL ANALYSES

Reeves

2nd Month

Treatment No.	T. N. ppm		NH_4-N ppm		NO_2-N ppm		NO_3-N ppm		O. M. %		Phosphorus ppm		pH	
1	843	872	1.3	2.3	.11	.14	33.51	32.14	1.27	1.30	17	14	8.45	8.50
2	941	1116	2.1	.6	.10	.12	57.14	59.02	1.35	1.30	15	17	8.40	8.45
3	804	884	6.1	7.2	.11	.09	50.63	51.14	1.30	1.28	28	22	8.35	8.40
4	1186	1066	4.0	4.2	.16	.14	76.47	74.52	1.34	1.30	14	11	8.36	8.35
5.	990	984	3.9	3.6	.28	.34	72.41	72.18	1.36	1.29	32	30	8.31	8.30
6	1246	1341	.2	.8	.16	.22	59.10	58.64	1.30	1.29	12	12	8.45	8.40
7	1147	1086	4.1	5.6	.28	.34	57.61	56.97	1.32	1.31	34	29	8.40	8.40
8	1321	1305	1.6	2.1	.10	.13	48.18	50.04	1.32	1.34	12	11	8.25	8.30
9	1119	1114	4.1	6.1	.11	.09	69.54	68.38	1.34	1.37	32	34	8.30	8.35
10	1086	1102	4.1	2.8	.09	.13	65.97	66.22	1.35	1.28	48	41	8.30	8.35

SOIL ANALYSES

Reeves

3rd Month

Treatment No.	T. N. ppm		NH_4-N ppm		NO_2-N ppm		NO_3-N ppm		O. M. %		Phosphorus ppm		pH	
1	967	917	9.2	8.9	.56	.47	35.16	36.18	1.30	1.35	17	15	8.64	8.60
2	915	956	14.1	13.4	.38	.42	73.25	76.19	1.30	1.37	14	13	8.50	8.55
3	816	914	10.4	8.6	.52	.74	73.62	75.67	1.30	1.35	37	40	8.45	8.47
4	1013	987	7.3	6.9	.22	.18	84.15	83.15	1.31	1.29	15	11	8.36	8.35
5	984	898	6.1	5.7	.64	.84	82.76	82.68	1.34	1.28	32	34	8.35	8.40
6	1132	1121	3.8	4.8	.48	.54	85.06	84.13	1.35	1.32	15	15	8.35	8.40
7	1105	1082	5.9	6.2	.58	.67	79.26	80.15	1.30	1.32	37	38	8.30	8.36
8	980	914	6.1	5.4	.52	.84	83.10	82.93	1.30	1.35	15	13	8.25	8.30
9	1015	992	6.9	7.5	.46	.48	90.19	89.28	1.30	1.30	38	36	8.30	8.32
10	1115	948	7.2	6.9	.64	.85	82.98	83.21	1.30	1.30	48	46	8.40	8.40

SOIL ANALYSES

Reagan

1st Month

Treatment No.	T. N.		NH_4-N		NO_2-N		NO_3-N		O. M.		Phosphorus		pH	
	ppm		ppm		ppm		ppm		%		ppm			
1	1326	1337	4.5	6.2	.16	.12	36.2	38.3	1.58	1.43	15	14	8.70	8.71
2	1768	1506	4.5	5.5	.09	.12	88.0	93.6	1.56	1.47	15	16	8.50	8.42
3	1115	1247	3.4	4.1	.14	.16	83.7	84.4	1.69	1.53	40	36	8.55	8.50
4	884	987	3.4	4.3	.14	.14	69.4	65.6	1.55	1.61	13	12	8.50	8.50
5	1576	1641	3.4	3.8	.13	.14	69.4	67.8	1.80	1.68	42	40	8.43	8.60
6	1038	1167	3.4	5.2	.12	.12	69.4	68.9	1.55	1.53	14	16	8.55	8.55
7	1211	1382	3.4	5.8	.10	.12	82.0	90.2	1.56	1.50	40	36	8.60	8.43
8	903	925	1.2	2.4	.09	.12	83.7	85.0	1.69	1.58	15	17	8.35	8.60
9	1057	1148	1.1	3.6	.11	.12	99.3	104.7	1.66	1.51	40	43	8.40	8.30
10	1115	1362	1.1	3.4	.09	.12	83.7	87.5	1.73	1.65	53	64	8.51	8.35

SOIL ANALYSES

Reagan

2nd Month

Treatment No.	T. N. ppm		NH_4-N ppm		NO_2-N ppm		NO_3-N ppm		O. M. %		Phosphorus ppm		pH	
1	1019	1218	2.2	3.4	.24	.31	36.8	39.5	1.80	1.61	12	15	8.30	8.40
2	942	842	1.2	2.6	.08	.12	65.2	69.4	1.56	1.51	13	15	8.23	8.18
3	730	658	.0	.8	.09	.12	75.2	80.1	1.73	1.62	35	36	8.18	8.20
4	1038	1247	.0	1.2	.13	.16	77.8	75.8	1.64	1.55	12	15	8.32	8.40
5	807	916	5.6	6.8	.33	.30	71.2	82.3	1.69	1.69	36	36	8.30	8.40
6	1115	1188	.0	3.2	.14	.12	56.0	49.6	1.61	1.74	10	12	8.40	8.35
7	942	1023	5.6	8.4	.27	.22	54.3	55.2	1.67	1.62	33	28	8.38	8.37
8	1057	1218	.0	1.1	.08	.12	44.3	47.7	1.55	1.54	11	17	8.20	8.25
9	1019	1256	4.5	3.8	.07	.12	68.9	73.6	1.66	1.46	34	38	8.20	8.25
10	942	1048	.0	.6	.06	.12	66.0	64.3	1.66	1.76	44	58	8.20	8.30

SOIL ANALYSES

Reagan

3rd Month

Treatment No.	T. N. ppm		NH_4-N ppm		NO_2-N ppm		NO_3-N ppm		O. M. %		Phosphorus ppm		pH	
1	1010	1064	10.1	8.2	.96	.62	56.6	61.4	1.69	1.64	14	15	8.46	8.52
2	807	925	7.9	7.4	.43	.42	89.8	90.1	1.69	1.49	15	15	8.27	8.25
3	961	1056	10.1	9.2	.70	.44	83.7	81.2	1.61	1.54	35	36	8.23	8.30
4	999	1142	6.7	5.6	.19	.30	82.8	89.8	1.69	1.73	14	14	8.30	8.35
5	1019	1284	5.6	6.2	1.07	.62	82.8	85.6	1.84	1.71	34	38	8.30	8.46
6	1076	1316	4.5	6.1	.35	.30	84.5	87.3	1.71	1.60	13	12	8.24	8.30
7	999	1085	5.6	4.5	1.07	.78	78.4	80.5	1.67	1.65	37	38	8.30	8.35
8	1038	1218	5.6	6.1	.70	.40	82.8	80.7	1.66	1.61	14	18	8.22	8.25
9	980	1034	6.7	6.5	.54	.86	89.8	96.8	1.73	1.55	37	42	8.20	8.25
10	961	986	6.7	8.0	.54	.54	82.8	94.9	1.86	1.75	49	61	8.29	8.35

SOIL ANALYSES

Reagan
Leached Straw

1st Month

Treatment No.	T. N. ppm	NH_4-N ppm	NO_2-N ppm	NO_3-N ppm	O. M. %	Phos-phorus ppm	pH	Lime %	T. S. S. %	K ppm
1	1038	48.3	.080	.90	2.49	24	8.90	9.39	.103	211.1
2	1826	88.8	.100	1.57	2.46	28	8.80	8.56	.110	235.7
3	1307	80.9	.110	1.06	2.44	36	8.75	9.30	.100	218.2
4	1595	60.7	.105	1.06	2.82	19	8.55	8.11	.090	183.0
5	1268	80.9	.080	.79	2.82	52	8.65	8.50	.103	211.1
6	1595	105.7	.100	1.01	2.42	34	8.85	8.58	.103	242.8
7	1307	84.3	.095	.73	2.64	47	8.62	9.06	.103	197.0
8	1518	78.7	.075	1.17	2.26	40	8.55	8.94	.130	253.3
9	1365	79.8	.075	1.01	2.44	45	8.75	9.44	.110	214.6
10	1365	86.6	.075	.95	2.46	58	8.60	9.81	.105	204.1

SOIL ANALYSES

Reagan
Leached Straw

2nd Month

Treatment No.	T. N. ppm	NH_4-N ppm	NO_2-N ppm	NO_3-N ppm	O. M. %	Phos-phorus ppm	pH	Lime %	T. S. S. %	K ppm
1	999	49.4	.040	12.21	2.71	23	8.20	9.94	.135	199.4
2	1365	89.8	.053	15.26	2.40	29	8.24	9.06	.140	215.0
3	1297	80.6	.055	.86	2.43	32	8.44	9.05	.131	219.8
4	1345	66.2	.040	.99	2.53	20	8.60	9.06	.108	215.0
5	750	81.9	.035	.52	2.38	40	8.58	9.99	.110	183.7
6	1249	11.2	.285	77.75	2.24	25	8.20	8.94	.160	234.6
7	1230	60.6	.040	1.31	2.26	39	8.40	8.94	.120	226.8
8	711	92.0	.043	.58	2.38	20	8.38	9.44	.127	222.8
9	980	75.2	.043	1.11	2.60	40	8.08	9.06	.140	250.2
10	1115	99.9	.060	.70	2.64	52	8.15	9.56	.140	234.6

SOIL ANALYSES

Reagan
Leached Straw

3rd Month

Treatment No.	T. N. ppm	NH_4-N ppm	NO_2-N ppm	NO_3-N ppm	O. M. %	Phosphorus ppm	pH	Lime %	T. S. S. %	K ppm
1	1115	48.3	.428	47.01	2.26	29	8.40	8.29	.142	222.8
2	1211	20.2	5.890	87.14	2.51	27	8.28	8.41	.156	215.0
3	1211	92.0	.107	.87	2.66	37	8.53	8.66	.140	203.3
4	942	86.4	.107	1.13	2.42	26	8.70	8.28	.106	246.3
5	1250	55.0	.482	2.35	2.64	42	8.32	8.91	.132	203.3
6	1422	35.9	1.615	88.88	2.24	35	8.08	9.46	.160	218.9
7	1365	101.0	.544	1.48	2.71	44	8.67	8.54	.100	230.7
8	1480	66.2	.268	1.83	2.60	27	8.20	9.04	.143	226.8
9	1192	69.6	.107	1.48	2.38	47	8.15	8.41	.145	238.5
10	1326	60.6	.187	1.48	2.62	66	8.23	8.54	.137	218.9

SOIL ANALYSES

Reagan
Non-leached straw

1st Month

Treatment No.	T. N. ppm	NH_4-N ppm	NO_2-N ppm	NO_3-N ppm	O. M. %	Phos-phorus ppm	pH	Lime %	T. S. S. %	K ppm
1	1345	38.2	.080	.76	2.89	25	8.50	8.94	.125	457.4
2	1268	92.2	.085	.95	2.46	27	8.55	8.13	.178	471.5
3	1153	68.6	.110	.40	2.40	48	8.35	8.25	.180	492.6
4	1365	69.7	.095	.73	2.78	24	8.40	8.06	.170	471.5
5	1634	74.2	.110	.95	2.49	65	8.45	8.74	.170	478.5
6	1345	36.0	.085	.85	2.57	26	8.45	8.58	.170	471.5
7	1307	67.4	.090	.79	2.46	42	8.30	8.83	.160	443.3
8	1441	85.4	.075	.67	2.89	24	8.45	8.58	.180	499.6
9	1845	87.7	.075	.90	2.71	44	8.38	8.58	.180	471.5
10	1345	73.1	.080	.76	2.75	66	8.45	8.58	.174	499.6

SOIL ANALYSES

Reagan
Non-leached straw

2nd Month

Treatment No.	T. N. ppm	NH_4-N ppm	NO_2-N ppm	NO_3-N ppm	O. M. %	Phos-phorus ppm	pH	Lime %	T. S. S. %	K ppm
1	750	58.4	.060	.99	2.38	21	8.12	8.83	.170	461.3
2	769	92.0	.040	.58	2.56	26	8.02	8.94	.200	523.9
3	1384	99.9	.043	.58	2.49	38	8.13	8.58	.175	516.1
4	1422	121.2	.040	.87	2.31	26	8.45	9.06	.170	523.9
5	769	111.1	.053	.52	2.46	41	8.25	9.06	.200	508.2
6	1057	76.3	.048	1.11	2.49	18	8.33	9.20	.180	570.8
7	884	94.3	.043	.52	2.40	38	8.20	8.58	.200	555.2
8	1230	84.2	.043	.76	2.56	24	8.15	8.58	.200	523.9
9	673	95.4	.035	.58	2.46	43	8.13	8.83	.190	578.6
10	1365	83.0	.058	.76	2.49	50	8.11	8.83	.180	586.4

SOIL ANALYSES

Reagan
Non-leached straw

3rd Month

Treatment No.	T. N. ppm	NH_4-N ppm	NO_2-N ppm	NO_3-N ppm	O. M. %	Phosphorus ppm	pH	Lime %	T. S. S. %	K ppm
1	1211	23.6	8.864	47.93	2.37	30	8.30	9.16	.250	477.0
2	1249	130.2	.536	5.84	2.73	25	8.31	8.66	.230	484.8
3	1211	42.6	13.818	50.28	2.27	46	8.20	8.04	.260	516.1
4	1307	59.8	.187	2.35	2.57	25	8.22	8.41	.190	555.2
5	1365	108.9	.482	1.74	2.51	20	8.10	8.41	.220	484.8
6	1249	47.1	.696	1.83	2.46	31	8.25	8.41	.195	539.5
7	1230	84.2	.482	1.48	2.60	27	818	8.29	.200	539.5
8	1326	69.6	.428	1.33	2.46	25	8.10	8.66	.210	555.1
9	1365	124.6	.134	1.22	2.51	34	8.25	8.79	.200	531.7
10	1326	59.5	.375	1.83	2.37	58	8.17	8.48	.185	516.1

Reagan
No Straw

	Lime %			T. S. S. %			K ppm		
	1st	2nd	3rd	1st	2nd	3rd	1st	2nd	3rd
1	7.79	8.58	9.46	.170	.120	.134	147.8	136.8	132.9
2	8.04	9.19	8.66	.142	.145	.150	151.3	125.1	144.7
3	8.19	8.45	8.29	.140	.145	.150	151.3	140.7	140.7
4	8.86	8.45	8.16	.140	.145	.150	144.3	140.7	136.8
5	8.14	9.31	8.91	.140	.150	.150	154.8	136.8	136.8
6	9.19	8.70	8.04	.140	.140	.150	144.3	144.7	164.2
7	9.06	9.70	7.80	.135	.133	.142	140.7	148.6	156.4
8	8.45	9.69	9.59	.150	.157	.150	161.9	152.5	152.5
9	8.34	9.31	8.16	.145	.158	.160	158.3	152.5	160.3
10	9.19	9.20	8.41	.135	.140	.140	140.7	156.4	152.5